Personalised Ambient Monitoring (PAM) for people with Bipolar Disorder

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Abstract: **This paper presents the architecture and preliminary trial results of a monitoring system for patients with bipolar disorder containing environmental and wearable sensors.**

Introduction

Almost 2% of the UK population have bipolar disorder, a group who, in their lifetime, will typically go through several episodes of manic or depressive behaviour. During such episodes a person's lifestyle and behaviour can change both rapidly and markedly leading to serious consequences. Many such people have well-developed self–awareness that is an important factor in the management of this condition with early recognition of symptoms of particular importance. If formalised, such assessment is usually diary based although PDA-based implementations are now also becoming available.

The aim of the Personalised Ambient Monitoring (PAM) project is to develop a support platform for people suffering from bipolar disorder. This platform will help patients to self monitor their mental state and also provide their care providers with accurate and informative data without compromising their privacy (at a mutually and previously agreed level.). Key research areas of the projects are: the development of a flexible sensor network providing data about patients' activities and behaviour; algorithms to process such data that can detect changes in patterns characterising a given patient; software to integrate these elements into a flexible platform alerting patient's clinicians and carers; and models of the above in relation to a sufferers mental health in order to assess the information content of the data collected and optimise the healthcare provision [1].

A flexible sensor network able to monitor activities that can be highly affected by bipolar disorder is key to the project. Requirements of these sensors are that they must not compromise patients' privacy and must be simple, both to implement and to use. The sensors can be divided into two groups: wearable and environmental. Decisions on the types of sensor to be deployed were made following discussion with a clinical psychologist and other experts in this field. The first group includes those carried by the patient throughout the day (e.g. location, activity, audio environment sensors). A component of this class is a mobile phone used as a sensor, data logger and communications channel. The second comprises ambient sensing units incorporated into the patients' home environments (to monitor audio environment, movement within the home, electrical appliance usage etc.).

This paper will present the sensor configurations used in the preliminary technical trial of PAM on volunteers with no history of bipolar disorder, along with the results obtained.

Sensor configurations

As described before, the target sensor configuration can be divided into two main groups: wearable and environmental. Sensors for both groups were selected based on their possible effectiveness in detecting activity changes in areas known to be influenced during the course of bipolar disorder (e.g. bed occupancy sensor for detecting lack of sleep in both depressive and manic episodes [2]). The following paragraphs describe sensors selected for the preliminary trial in both groups.

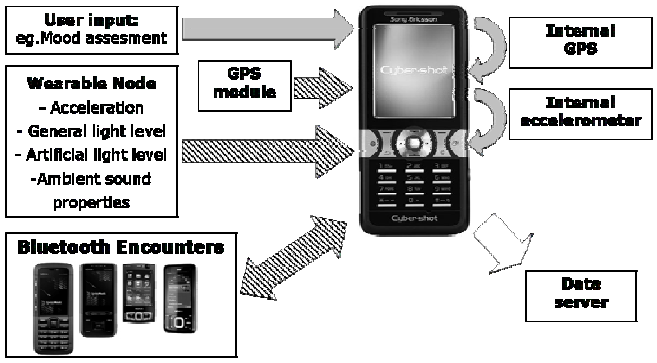

Figure 1 Wearable sensor set (Bluetooth links are shown with striped arrows).

Wearable sensors

As seen in fig. 1, the main element of the wearable sensor set is a mobile phone a common appliance capable of: connecting to local RF devices using Bluetooth; processing data streams; and transmitting data packets using protocols such as GPRS or HSDPA. This functionality is accessible even in mid-range phones from all suppliers. Additionally, depending on the device, a mobile phone can give access to internal resources that could be utilised as a sensor input for monitoring activity (e.g. built in GPS or tilt-sensing accelerometer). The mobile phone used for Personalised Ambient Monitoring is equipped with an application operating in the background which performs communication with other wearable devices, implements pop up self-assessment questionnaires and if needed can perform basic processing on incoming data prior to storage. Additionally it performs scans for other Bluetooth-enabled devices in range (especially other mobiles) which can correlate with the current social environment [3]. In order to maximise compatibility the application was developed using universal Java interface which should work on all Java-enabled phones, regardless of brand.

Using the phone as a processing and storage node resulted in utilising Bluetooth as a main wireless connectivity standard for the other wearable devices used in the design. These are: an off-the-shelf GPS unit (which is an option for phones without built-in GPS module) and a custom made belt-worn device that incorporates a microphone acquiring basic features of ambient sound (e.g. zero crossing rate) that it is possible to process to infer the profile of surrounding environment [4]. Another sensor included is a light detector able to determine both ambient light level and whether it is from a natural source. The device also incorporates a three axis accelerometer for monitoring users' activity [5].

Environmental Sensors

The second group of sensors selected for the technical trial consist of mostly off-the-shelf devices for indoor monitoring. The list includes: Passive Infra-Red motion detectors, wall-mounted camera, bed occupancy mat, and a custom made set top device with sensors for monitoring light levels, ambient sound (as in the wearable unit) and additionally appliance remote control activity.

Initial experiment

During the initial testing particular parts of the system were tested on volunteers with no history of bipolar disorder, the aim being to validate the technology before the full trials.

For preliminary tests the participant carried some or all components of the wearable set during the day with sensor data recorded on the phone. The emphasis of this initial trial concerned the reliability of the sensors, suitability for long-term monitoring (including operating duration) and their acceptance by the users

Discussion

The tests showed that system is reliable and can provide all-day activity monitoring. Despite increased power consumption, due to maintaining Bluetooth connections, it is possible to use the mobile phone on a normal basis recharging it approximately every 24 hours. Even simple combinations of results (e.g. Bluetooth encounters with position record) show emerging patterns which is promising for further tests and research.

Future work will focus on further integration of platform elements, capturing behaviour patterns from acquired data and attempting to build a reliable model of the conditions progression. Software will be enhanced using a dynamic rule engine to enable firmware changes without supervision and reprogramming of the whole system.

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